



Monique Gueudet-Bornstein. *Stéphane Grappelli*. 1997.

Laparoscopy provides equivalent oncologic outcomes, comparable complication rates, and improved perioperative morbidity compared to standard open surgical techniques for managing kidney cancers.

Laparoscopic Management of Kidney Cancer: Updated Review

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Background: Laparoscopy has emerged as the preferred option for the surgical management of kidney cancer. Although many reports have been published regarding the operative outcome of renal cell carcinoma (RCC) and upper-tract transitional cell carcinoma (TCCA) treated laparoscopically, few review the oncologic outcome of these pathologies treated with laparoscopic techniques.

Methods: We review the literature regarding the laparoscopic approaches, the complications related to laparoscopic surgery, and the long-term oncologic results of laparoscopic radical nephrectomy, partial nephrectomy, and nephroureterectomy.

Results: Laparoscopic radical nephrectomy has become the new standard of care for most patients with suspected RCCs that are not amenable to nephron-sparing procedures. Laparoscopic techniques for managing RCC and TCCA are safe, follow well-established guidelines for surgical dissection, and meet or exceed perioperative convalescence and oncologic outcomes compared to traditional open procedures. The surgical techniques and the long-term outcome data for laparoscopic partial nephrectomy continue to mature.

Conclusions: Laparoscopy is a minimally invasive option available to most patients with kidney cancer. The immediate benefits of laparoscopy are well established and include less estimated blood loss, decreased pain, shorter perioperative convalescence, and improved cosmesis. Long-term oncologic outcomes of patients treated laparoscopically for kidney tumors resemble those of the open surgical approach.

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Abbreviations used in this paper: RCC = renal cell carcinoma, TCCA = transitional cell carcinoma, LRN = laparoscopic radical nephrectomy, LPN = laparoscopic partial nephrectomy, LNU = laparoscopic nephroureterectomy.

Introduction

Minimally invasive options for managing patients with kidney cancers are evolving rapidly. Since the first report of a laparoscopic radical nephrectomy (LRN) by Clayman et al¹ in 1991, laparoscopy has gained rapid acceptance as the new standard of care for removing kidneys suspected of harboring a renal cell carcinoma (RCC) or transitional cell carcinoma (TCCA). Pioneers in laparoscopy have elegantly demonstrated equivalent oncologic outcomes, comparable complication rates, and improved perioperative morbidity for patients undergoing laparoscopic procedures compared to standard open surgical techniques for managing kidney cancers.^{2,9}

With innovative equipment design and increasing surgeon experience, laparoscopic techniques can now be considered in the management of most patients who are candidates for radical nephrectomy, nephroureterectomy, and nephron-sparing procedures. This paper presents the indications, operative procedures, and outcomes of renal tumors treated with laparoscopic techniques.

Diagnosis and Staging of Kidney Cancer

The preoperative assessment of patients with a kidney tumor has three principal aims: to make the diagnosis of RCC or TCCA, to assess the stage of disease, and to delineate the anatomic detail necessary for operative planning. Patients with RCC can present with many different signs and symptoms attributable to the primary tumor, although the classic triad of flank pain, a palpable mass, and hematuria is increasingly uncommon. Today, with the frequent use of cross-sectional imaging, the majority of RCCs are diagnosed incidentally during the investigation of unrelated complaints.¹⁰ Upper-tract TCCA is usually detected during the workup of gross or microscopic hematuria.

RCCs comprise 85% to 90% of renal parenchymal tumors that are radiologically demonstrated to be solid. Differentiation of renal cysts exhibiting complex features such as thickness, nodularity, calcification of the cyst wall, internal septations, or heterogeneity is mandatory, and a systematic assessment using these objective criteria facilitates the estimation of the risk of malignancy.¹¹ Needle biopsy of renal masses is prone to inaccuracy.^{12,13} Other than for suspected metastases or lymphoma, biopsy is not routinely recommended for making management decisions.^{14,15} Upper-tract TCCAs typically appear as collecting system filling defects on contrast-enhanced studies. The diagnosis of TCCA and differentiation from other filling defects (eg, stones, blood clots, papillary necrosis, fungus) are established with a com-

bination of radiographic studies, urinary cytology, urinary biomarkers, and possibly ureterorenoscopy with or without tissue biopsy.

Clinical staging of kidney cancers requires radiologic assessment of the extent of local or distant disease. Imaging of the chest, abdomen, and pelvis should be performed with computed tomography (CT) or a combination of CT with magnetic resonance imaging or standard chest radiograph. Laboratory biochemical evaluation includes a routine complete blood count and a complete metabolic panel specifically evaluating the serum creatinine, blood urea nitrogen, liver function tests, serum calcium, and alkaline phosphatase. If the patient complains of atypical musculoskeletal discomfort or if the biochemical studies indicate possible bone metastases, a bone scan should be considered. Presently, positron-emission tomography is not considered part of the staging workup for the newly diagnosed kidney cancer when other diagnostic studies reveal no evidence for systemic disease.¹⁶ The advances in imaging technology have dramatically enhanced the visualization of anatomic detail, especially vascular anatomy. Such detail is crucial for nephron-sparing cases.

Selection of Patients for Laparoscopic Surgery

Although most patients with kidney cancer could be managed with laparoscopic techniques, careful patient selection is paramount to achieving successful outcomes. Patients with moderate to severe cardiopulmonary comorbidities require careful preoperative assessment due to the physiologic disturbances brought about by the mechanical effects of abdominal insufflation and hypercarbia associated with a carbon dioxide pneumoperitoneum. A detailed history is crucial to identify patients with an uncorrected coagulopathy, extensive prior abdominal and pelvic surgeries, mesh hernia repairs, and previous intra-abdominal infections or abscesses due to a perforated viscus. Open surgical procedures or other management options should be strongly considered in these scenarios. Patients with organomegaly, iliac or aortic aneurysms, umbilical hernias, and prior abdominal surgery might require alternative sites for trocar placement or initial open access utilizing the Hasson technique.¹⁷ Other relative contraindications to laparoscopic renal surgery include abdominal ascites and pregnancy. Obese patients undergoing laparoscopic renal surgery have improved perioperative outcomes including decreased blood loss, narcotic requirements, time to oral intake, length of hospital stay, and convalescence.^{18,19} However, complication rates are possibly higher due to technical factors such as the inadequate



Fig 1. — Right renal mass in a 61-year-old man. A transperitoneal LRN was performed and final pathology revealed a stage T2 (>7 cm) clear cell RCC.

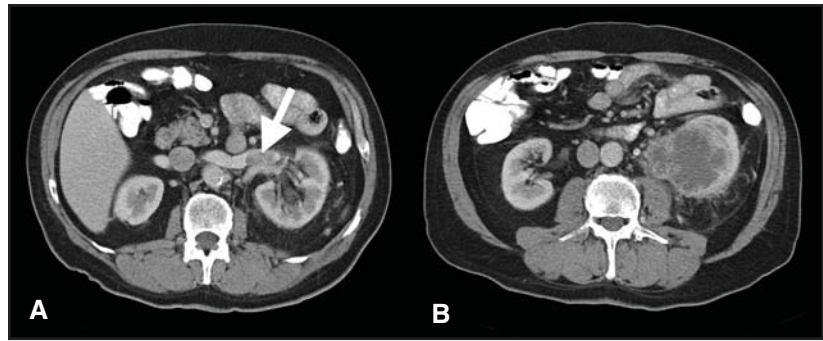


Fig 2A-B. — Left renal mass in a 68-year-old man. (A) Tumor thrombus was visualized in the left renal vein (arrow). (B) A hand-assisted, left radical nephrectomy was performed. Final pathology revealed stage T3b clear cell RCC.

length of operating instruments, the need for increased insufflation pressures to elevate the abdominal wall, and the higher amounts of intra-abdominal mesenteric and retroperitoneal fat, all of which make orientation more challenging.¹⁹

Laparoscopic Radical Nephrectomy

Laparoscopic techniques for managing RCC should be safe, should follow well-established guidelines for surgical dissection, and should meet or exceed perioperative convalescence and oncologic outcomes compared to traditional open techniques. Today, laparoscopy has evolved into the primary modality for managing renal tumors, and three techniques are three well-accepted for performing an LRN. A “pure” LRN is approached most frequently via a transperitoneal route, although as experience increases, urologists are recognizing the familiarity and the advantages of a retroperitoneal approach. Many urologists have adopted a hand-assisted technique for LRN that affords patients the advantages of a laparoscopic procedure and permits the surgeon to use the operating hand for tactile feedback, surgical dissection, and surgical retraction. Knowledge and comfort with each of these approaches to LRN allows for broader laparoscopic application and patient selection for managing patients with clinical T1 to T3 renal tumors (Figs 1 and 2A-B).

Transperitoneal Laparoscopic Radical Nephrectomy

Transperitoneal LRN begins with careful patient positioning as described previously (Figs 3A-B).²⁰ A Foley catheter and an oral-gastric tube are placed. For right-sided tumors, 4 to 5 trocars are required (camera port, working ports, liver retraction port) (Fig 4A). For left-sided tumors, 3 to 4 trocars are utilized (Fig 4B). Adapting trocar placement according to the patient’s body habitus and previous surgical history is essential to achieving a successful outcome. In obese patients, the medial trocars are adjusted to the paramedian location

as the bowel often obscures visualization of the kidney and the renal hilum. This maneuver also decreases the distance between the abdominal wall and the renal structures, thereby compensating for the inadequate length of the instrumentation. A pneumoperitoneum is established with either a Veress needle or via an open

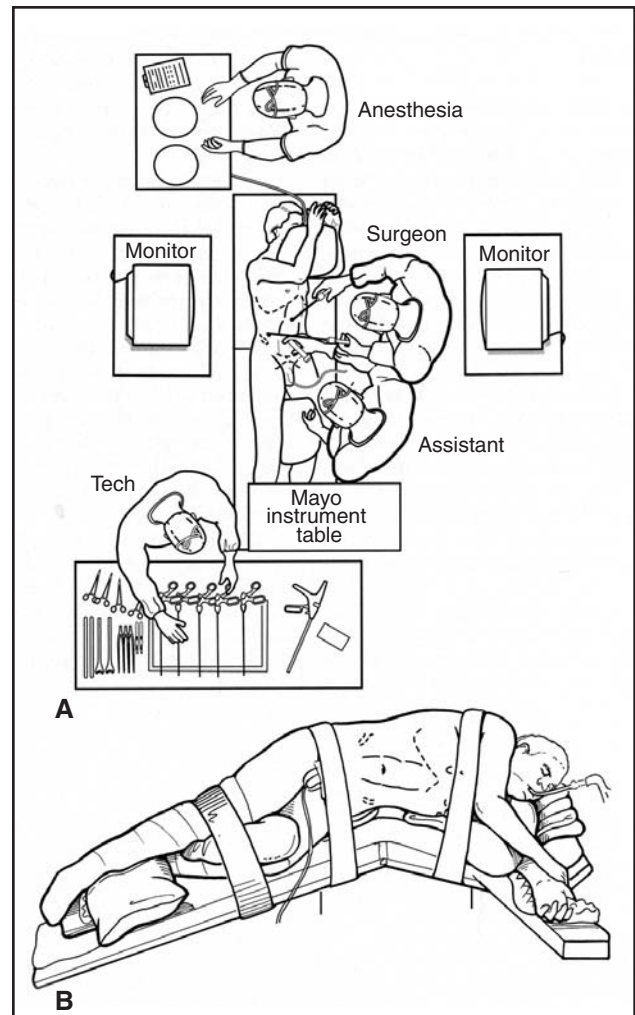


Fig 3A-B. — Operative room arrangement (A) and patient positioning (B) for LRN. From Bishoff JT, Kavoussi LR, eds. *Atlas of Laparoscopic Retroperitoneal Surgery*. 1st ed. Philadelphia, Pa: WB Saunders; 2000. Reprinted with permission from Elsevier.

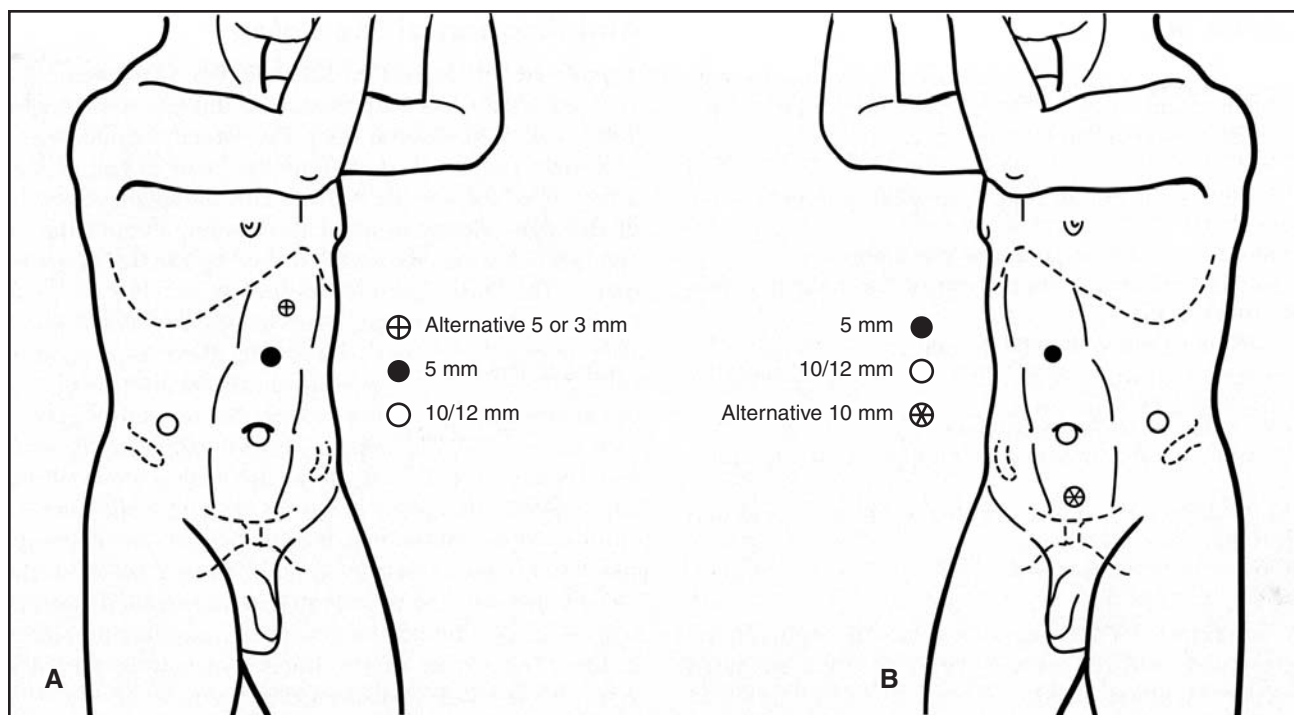


Fig 4A-B. — Trocar placement for a right-sided (A) and left-sided (B) transperitoneal LRN. From Bishoff JT, Kavoussi LR, eds. *Atlas of Laparoscopic Retroperitoneal Surgery*. 1st ed. Philadelphia, Pa: WB Saunders; 2000. Reprinted with permission from Elsevier.

Hasson technique. The abdomen is insufflated with CO₂ to a maximum pressure of 15 mmHg (12 to 15 mmHg).

Laparoscopic dissection is identical to open techniques for radical nephrectomy. The colon is carefully mobilized to avoid initial dissection lateral and posterior to Gerota's fascia. A strip of posterior peritoneum is left intact over the anterior lateral aspect of the kidney. For right-sided tumors, the duodenum is kocherized, and the inferior vena cava and renal vein are skeletonized. Thereafter, the lower pole of the kidney is dissected identifying the psoas muscle fascia and the lateral aspect of the vena cava as landmarks. Typically, the right gonadal vein is left in situ. The renal hilum is identified and the renal artery and vein are sequentially divided with an endovascular stapler or between clips. The renal hilum should be controlled individually starting with the artery and then the vein, although recent data confirm that the renal hilum can be safely divided en bloc with an endovascular stapler.^{21,22} This technique is used at our institute in emergency situations where the hilum is difficult to dissect or in case of hilar bleeding. If there is a large upper-pole tumor or the adrenal gland appears abnormal on preoperative radiographic imaging studies, the adrenal gland is resected with the specimen. Otherwise, the adrenal gland is not routinely excised.² Finally, the hepatorenal ligament and the lateral fascia attachments are divided, releasing the surgical specimen. The pneumoperitoneum is decreased to observe the renal fossa for hemostasis. Thereafter, the specimen is placed into a lap-sac through one of the 10- to 12-mm trocar sites. Prior to

retrieving the specimen by extending the trocar incision, the remaining 10- to 12-mm trocar sites are closed under direct vision with a port closure device; 5-mm trocar sites are not closed. For left-sided tumors, care is required during mobilization of the splenic flexure to avoid tearing the splenic capsule secondary to adhesions between the spleen and the omentum or the splenocolic ligament. As the descending colon is reflected medially, the distal pancreas is identified and care is taken to avoid injury to the splenic artery and vein. The gonadal vein is identified along with the ureter. We commonly dissect the gonadal vein up to the left renal vein prior to division of the gonadal vein and ureter. The psoas fascia is identified and the lower pole of the kidney is mobilized. The surgical dissection proceeds just lateral to the aorta until the left renal hilum is encountered. For left-sided tumors, additional caution is warranted during dissection of the left renal vein to avoid injury to or bleeding from gonadal, adrenal, and lumbar tributaries. The surgeon might need to divide any one or all of these structures during dissection and division of the left renal hilum. Completing a left radical nephrectomy is similar to right-sided procedures from this point.

Multiple series demonstrate the advantages of LRN compared to standard open surgery. These advantages include reduced estimated blood loss, decreased pain medication requirements, faster return of bowel activity, shorter length of hospital stay, decreased wound infection rates, faster convalescence, and improved cosmesis.²⁻⁵

The long-term oncologic efficacy of transperitoneal LRN is comparable to open radical nephrectomy (Table 1).^{3,7-9,23,24} Generally, patients undergoing open radical nephrectomy have larger tumors. Permpongkosol et al²³ recently reported equivalent 10-year disease free, cancer specific, and actuarial survival rates of 94%, 97%, and 76%, respectively, for transperitoneal LRN, compared with 87%, 86%, and 58% for open radical nephrectomy. When stratified into T1 and T2 categories, patients undergoing transperitoneal LRN had 10-year disease-free, cancer-specific, and actuarial survival rates of 98%, 98%, and 75%, respectively, compared to 84%, 95%, and 81%. However, the data comparing open radical nephrectomy to LRN are based on comparative studies; randomized prospective trials have not been performed.

Hand-Assisted Laparoscopic Radical Nephrectomy

Nakada et al²⁵ described the hand-assisted LRN in 1997. Many series have since compared hand-assisted LRN to standard open techniques and to transperitoneal LRN (Table 2).²⁶⁻³⁰ Harano et al²⁶ compared the 4-year disease-free and overall survival for patients undergoing hand-assisted LRN and open radical nephrectomy. The survival rates for hand-assisted LRN were 88% and 100%, respectively, compared with 93% and 100% for the open nephrectomy group.

Patient preparation and positioning is identical to that described for transperitoneal LRN. The hand-assisted LRN technique usually begins with a 6- to 8-cm incision for hand-port placement through a lower quadrant Gibson-type incision (Fig 5A) or through the lower mid-

Table 1. — Laparoscopic Radical Nephrectomy (LRN) Compared to Open Radical Nephrectomy

Series (year)	Technique	No. of Patients	Mean Tumor Size (cm)	Median Follow-up (mos)	Calculated 5-Yr Disease-Free Survival Rate (%)	5-Yr Cancer-Specific Survival Rate (%)	5-Yr Actuarial Survival Rate (%)	Mean EBL (mL)	Hospital Stay (days)
Permpongkosol et al ²³ (2005)	LRN	67	5.1	73	94	97	85	NR	NR
	Open	54	5.4	80	87	89	72	NR	NR
Chan et al ⁷ (2001)	LRN	67	5.1	36	95	NR	86	289	3.8
	Open	54	5.4	44	86	NR	75	309	7.2
Ono et al ⁸ (2001)	LRN	103	3.1	29	95	NR	95	245	NR
	Open	46	3.3	39	90	NR	96	465	NR
Portis et al ⁹ (2002)	LRN	64	4.3	54	92	98	81	219	4.8
	Open	69	6.2	69	91	92	89	345	7.4
Dunn et al ³ (2000)	LRN	61	5.3	25*	91.4**	NR	NR	172	3.4
	Open	33	7.4	27.5*	90**	NR	NR	451	5.2
Saika et al ²⁴ (2003)	LRN	195	3.7	40	91	NR	94	248	NR
	Open	68	4.4	65	87	NR	94	482	NR

* mean.
** 2-year rate.
NR = not reported, EBL = estimated blood loss.

Table 2. — Hand-Assisted LRN (HALRN) Compared With Transperitoneal LRN (TLRN) and Standard Open Procedures

Series (year)	Technique	No. of Patients	Mean Tumor Size	Mean EBL (mL)	Mean Operating Room Time (mins)	Complication Rate (%)	Hospital Stay (days)
Harano et al ²⁶ (2005)	HALRN	96	4.3	251	246	10.4	11.4
	Open	78	4.9	343	297	9.3	16.2
Shuford et al ²⁸ (2004)	HALRN	18	4.8	258	NR	17	1.9
	Open	41	7.4	371	NR	10	3.6
Nakada et al ²⁹ (2001)	HALRN	18	4.5	170	220	17	3.9
	Open	18	6.4	237	118	17	5.1
Kawauchi et al ³⁰ (2002)	HALRN*	22	NR	170	204	9	11.5
	Open	22	NR	495	234	18	21.5
Nelson and Wolf ²⁷ (2002)	HALRN	22	6.3	191	205	23	2.7
	TLRN	16	4.1	289	270	13	2.4

* retroperitoneal HALRN, NR = not reported, EBL = estimated blood loss.

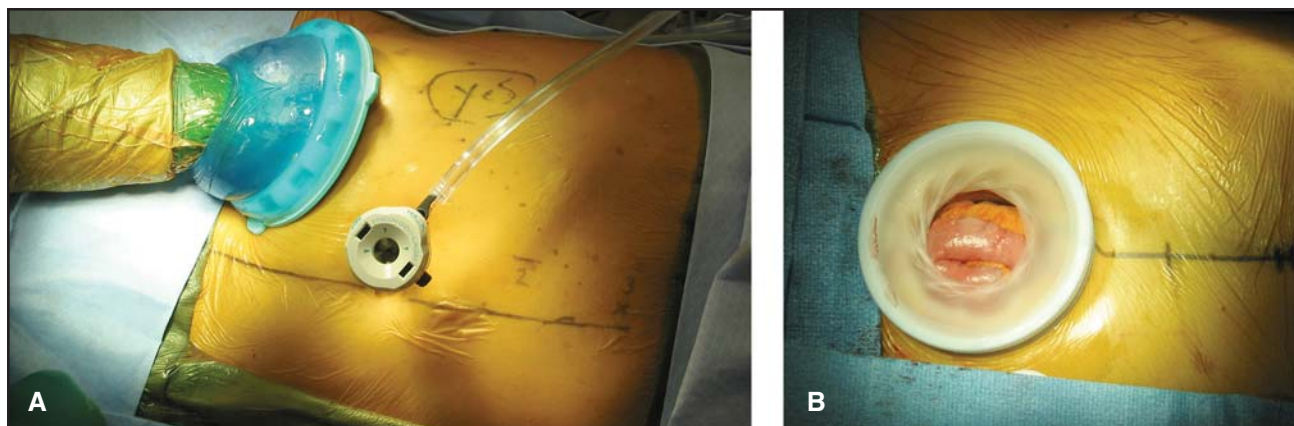


Fig 5A-B. — (A) Right lower quadrant hand-port placement for hand-assisted right radical nephrectomy, and (B) lower midline hand-port placement for hand-assisted right radical nephrectomy.

line abdomen (Fig 5B). Several hand ports are available, and the specific type used depends on surgeon preference. Trocar positioning and surgical dissection proceeds according to principals outlined for transperitoneal LRN. After the specimen is released and hemostasis is ensured, the specimen is removed through the hand-port site within a laparoscopic sac.

Hand-assisted LRN has the advantage of a quicker learning curve, especially for previously trained urologists who want to incorporate the well-established benefits of laparoscopy into their urologic practices.³¹ One hand in the operative field may facilitate retraction, dissection, hemostasis, and tactile sensation similar to that experienced with open surgery. Disadvantages of hand-assisted LRN include hand fatigue for the operating surgeon and reportedly higher rates of abdominal pain and wound complications for the patient (ie,

wound infections and incisional hernias).^{27,32,33} The etiology of hand fatigue is multifactorial and may depend on increased pressure in the pneumoperitoneum, inadequate incision for hand size, and poor position height of the surgical table.³⁴

Retroperitoneal Laparoscopic Radical Nephrectomy

Gaur et al³⁵ introduced the retroperitoneal approach for LRN in 1993. Retroperitoneoscopy has the advantage of quick access to the renal artery and vein that allows early vascular control followed by dissection of the surrounding kidney and tumor beyond Gerota's fascia. The adrenal is resected en bloc with the renal specimen if required.³⁶ Limited working space is a disadvantage with this technique. However, as surgeons become fastidious with this approach, their ability to appropriately develop and enlarge the retroperitoneum improves, allowing larger tumors to be resected and more patients to experience the benefits of laparoscopic surgery. This technique is particularly useful for patients who have undergone multiple prior abdominal surgeries and who generally have smaller tumors, although kidneys harboring tumors up to 12 cm have been removed with this approach.³⁷

Patients are placed in the full flank position. Usually, the operating table is flexed and the kidney rest is elevated, thereby increasing the space between the iliac crest and the lower ribs. Retroperitoneal access is obtained through a small 10- to 15-mm incision just below and medial to the tip of the 12th rib (Fig 6A). The muscle and fascia are separated using a blunt instrument,

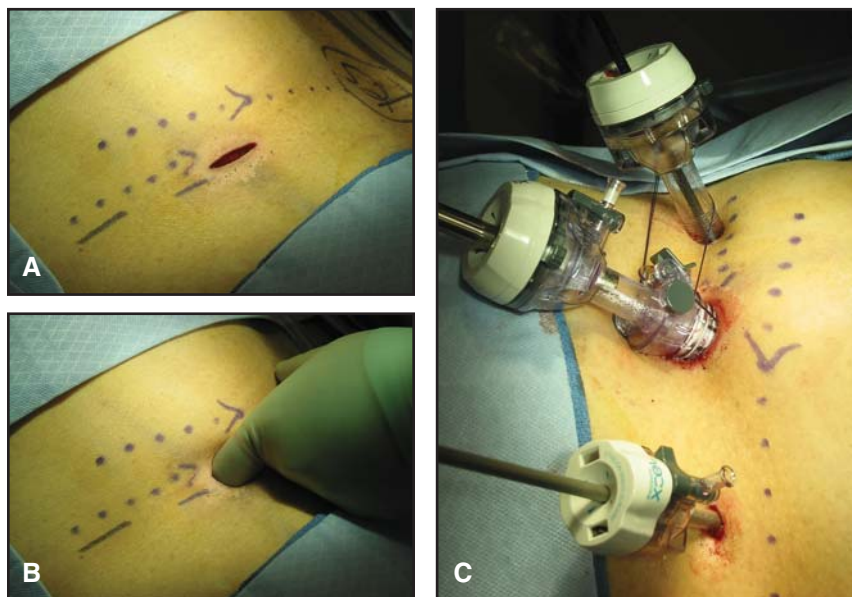


Fig 6A-C. — (A) Access for a right retroperitoneal laparoscopic radical nephrectomy. A 10- to 15-mm incision is made below and medial to the tip of the 12th rib. (B) The flank muscles are pierced with a blunt-tipped instrument followed by finger dissection and development of the retroperitoneum space to permit trocar placement. (C) Trocar placement for a right retroperitoneal LRN.

allowing one finger to develop a working space posterior to the kidney above the psoas muscle (Fig 6B). Often the lower pole of the kidney is immediately palpated. The colon is separated away from the anterolateral abdominal wall with the index finger. Several techniques, including balloon insufflation, are utilized to develop the retroperitoneum.³⁵ Additional trocars are placed below the 12th rib just above the psoas muscle posteriorly, and then more anteriorly through the lateral abdominal wall under direct vision using the laparoscope (Fig 6C). Anatomical orientation is different from the intraperitoneal radical nephrectomy. On the left side, the classic landmarks for orientation include the ureter and the left gonadal vein. The lumbar vein should not be confused for the renal vein, before securing the hilum. On the right side, the classic landmarks include the inferior vena cava and the ureter. The adrenal gland should be carefully dissected if a standard radical nephrectomy is the goal before blunt dissection of the specimen is started.

Recent reports demonstrate success with retroperitoneal LRN (Table 3).^{36,38-40} Desai et al³⁸ published a prospective randomized trial comparing retroperitoneal LRN to transperitoneal LRN. The retroperitoneal technique was associated with more rapid arterial and venous control and decreased total operative time (150 vs 207 minutes). Both modalities were similar in estimated blood loss, complication rates, analgesia requirements, and length of hospital stay. In a separate prospective, randomized study comparing retroperitoneal LRN to transperitoneal LRN, Nambirajan et al⁴¹ found no differences in estimated blood loss, length of surgery, transfusion rates, analgesic requirements, and length of hospital stay. However, all patients who underwent retroperitoneal LRN resumed oral intake the day following surgery compared to 75% of patients in the transperitoneal LRN group. Finally, Berglund et al⁴² demonstrated that retroperitoneal LRN could be performed successfully in obese patients (BMI ≥ 40 kg/m²). Obese patients undergoing retroperitoneal LRN had more favorable estimated blood loss, operative

times, conversion rates, and hospital stay, although the outcome did not reach significance compared with obese patients managed with transperitoneal LRN.

Laparoscopic Partial Nephrectomy

Historically, a partial nephrectomy was recommended only for patients with imperative or relative indications for renal preservation. These indications included patients with bilateral kidney tumors, renal insufficiency, or a solitary kidney, as well as patients whose risk for renal deterioration or compromise was associated with urolithiasis, diabetes, or other medical comorbidities. As the efficacy of partial nephrectomy was established in comparison to radical nephrectomy,^{43,44} surgeons expanded recommendations for partial nephrectomy to patients with unilateral, unifocal renal tumors less than or equal to 4 cm in maximum dimension.⁴⁵ Presently, many surgeons believe that elective partial nephrectomies can be offered safely to patients with tumors up to 7 cm in size without compromising cancer control and survival.⁴⁶

Laparoscopic partial nephrectomy (LPN) was introduced several years ago by Winfield et al.⁴⁷ Traditional open partial nephrectomies are typically performed through flank incisions with or without a partial rib resection. Among the many benefits of LPN include decreased pain and improved perioperative convalescence.⁴⁸ While initial reports of LPN were associated with significant complication rates, the experience from more recent series of patients (performed by experienced urologists with advanced laparoscopic skills) compares favorably to complications reported using standard open techniques.^{48,49}

Large numbers of patients — most with tumors less than 4 cm in size — are managed successfully with laparoscopic nephron-sparing procedures (Table 4).⁴⁹⁻⁵³ An LPN is ideal for the patient with an exophytic, small, and peripherally located renal tumor (Fig 7). However, increasing experience and advanced laparoscopic training are commensurate with more LPNs being offered to patients with challenging cT1b (4 to 7 cm) and cT2 (>7 cm) renal tumors^{49,54,55} and with tumors situated in the

Table 3. — Efficacy of Retroperitoneal LRN

Series (year)	No. of Patients	Mean Tumor Size (cm)	Mean Operating Room Time (mins)	Mean EBL (mL)	Mean Hospital Stay (days)	Major Complication Rate (%)
Cicco et al ³⁹ (2001)	50	3.9	139	150	6	4
Batler et al ³⁶ (2001)	12	91.2 cc ^{3*}	256	142	4.4	8
Abbou et al ⁴⁰ (1999)	29	4	145	80	3	7
Desai et al ³⁸ (2005)	52	5	150	242	2	7.7

* calculated as tumor volume, EBL = estimated blood loss.

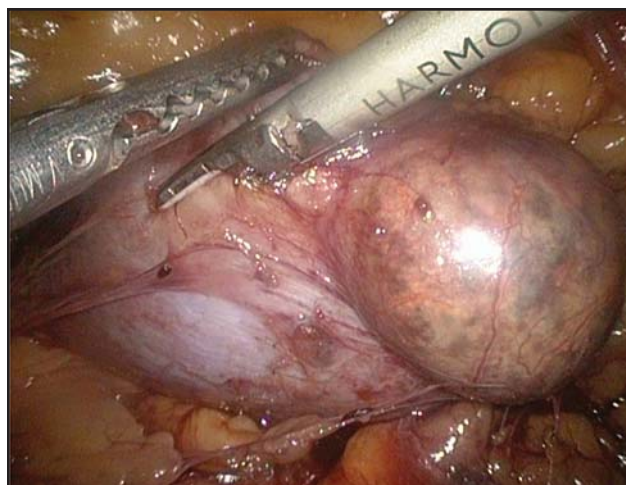


Fig 7. — Retroperitoneal laparoscopic left partial nephrectomy.

renal hilum.^{56,57} The surgeon's choice of a transperitoneal or retroperitoneal approach is influenced by not only the location and size of the renal mass, but also the surgeon's experience. A retroperitoneal LPN has been associated with decreased operating time, reduced estimated blood loss, and faster consumption of solid foods.⁵⁰ These outcomes may be associated with a patient selection bias. Ng et al⁵⁸ found that their patients who underwent LPN using a transperitoneal approach compared with patients who underwent a retroperitoneal LPN had larger tumors (3.2 cm vs 2.5 cm), required more calyceal repairs (79% vs 57%), and had slightly longer warm ischemic times (31 minutes vs 28 minutes), operative times (3.5 hours vs 2.9 hours), and length of hospitalizations (2.9 days vs 2.2 days). No differences were seen in blood loss and complication rates.

Several methods are available to decrease bleeding while excising the renal tumor. These methods include manual compression, radiofrequency ablation or other energy sources, and renal vascular clamping.^{59,61} Clamp-

ing the renal hilum is not required in every case, particularly for tumors limited to the renal cortex or outer medulla. These tumors can be excised with cold scissors, cautery, and ultrasonic shears. Bleeding is managed with several commercially available hemostatic agents.^{59,61} Selective clamping of the renal hilum is the preferred approach, particularly for larger tumors, centrally located hilar tumors, and lesions extending deep into the medullary region or into the sinus fat. Vascular control results in less active parenchymal bleeding, permits better visualization of the parenchymal defect, and allows more accurate suture approximation of the collecting system if closure is required. Some surgeons advocate cystoscopy and placement of an externalized ureteral stent immediately before the LPN.⁵⁰ The stent is used for the retrograde injection of diluted methylene blue or indigo carmine to help locate a collecting system entry and to subsequently test the closure for persistent urinary extravasation. However, Bove et al⁶² reviewed their experience and found a very low number of leaks regardless of ureteral stent placement. Their results did not support routine ureteral stenting to prevent urine leaks following LPN.

The primary concern regarding vascular control is the effect of warm ischemia on renal function. Bhayani et al⁶³ evaluated changes in the serum creatinine 6 months following surgery in 118 patients with a normal contralateral kidney who underwent LPN with or without renal hilar clamping. Patients were stratified into three groups: no hilar occlusion, occlusion for less than 30 minutes, and occlusion for greater than 30 minutes. The mean increase in the serum creatinine at 6 months in each patient group did not change significantly and was demonstrated to be 0.05, 0.06, and 0.08 mg/dL, respectively. Desai et al⁶⁴ found no differences in the mean postoperative serum creatinine in patients with longer warm ischemic times (mean of 30 minutes)

Table 4. — Laparoscopic Partial Nephrectomy (LPN)

Series (year)	No. of Patients	Mean Tumor Size (cm)	Mean Operating Room Time (mins)	Mean EBL (mL)	Transfusion (%)	Urine Leak (%)	RCC (%)	Positive Margin (%)	Local Recurrence (%)	Major Complication Rate (%)	Mean Follow-Up (mos)
Link et al ⁵¹ (2005)	217	2.6	186	385	6.9	1.4	66.4	3.5	1.4	5.5	37.7
Moinzadeh et al ⁵² (2006)	100	3.1	187	219	3	NR	68	2	0	NR	42.6
Permpongkosol et al ⁴⁹ (2006)	85*	2.4	225	436	6	1.2	100	2	2	7	40.4
Ramani et al ⁵³ (2005)	200	2.9	198	247	9	4.5	NR	NR	NR	**	NR
Wright and Porter ⁵⁰ (2005)	51	2.3	252	270	0	4	73	4	NR	8	25.6

NR = not reported, EBL = estimated blood loss, * only patients with RCC included, ** could not be calculated.

who required collecting system closure compared to patients without a recognized collecting system entry and a mean ischemic time of 19.4 minutes. Generally, warm ischemic times of 30 minutes or less are well tolerated by patients with normal renal function and normal contralateral kidneys. Patients with advanced age, with possible underlying medical renal disease, or with preexisting azotemia have an elevated risk of renal insufficiency after LPN.⁶⁵ Small changes in serum creatinine may not reflect nephron loss or damage. Future studies may incorporate estimates of creatinine clearance as a better indicator of renal compromise.

Positive margin rates for LPN are comparable to open series of partial nephrectomies.⁶⁶ A standard practice during partial nephrectomy is to send the specimen for frozen section to evaluate the surgical margin. Usually, additional tissue is resected if the margin is positive for cancer. Permpongkosol et al⁶⁷ recently reported the outcome of 9 patients who elected surveillance or completion nephrectomy after a positive surgical margin. One patient with Von Hippel Lindau disease died of metastases, and 6 other patients on surveillance had no evidence of a local or distant cancer recurrence at a median follow-up of 32 months. Two patients who underwent a radical nephrectomy had no evidence of cancer on final pathology. Achieving negative margins should remain a priority for surgeons performing LPNs, and every effort should be exercised to accomplish this intraoperatively for malignant tumors. However, if the final pathology report indicates a positive margin, careful surveillance can be considered as opposed to completion nephrectomy, especially if positive margins are microscopic and focal or if the tumor was benign.

The short- and intermediate-term oncologic outcomes of patients undergoing LPNs for RCC have been reported. Allaf et al⁶⁸ experienced no recurrences in 46 (95.8%) of 48 patients treated with LPN after a mean follow-up of 3 years. Recurrence was reported in 2 patients. One patient had Von Hippel Lindau disease and a local recurrence near the site of resection 18

months following surgery. After 46 months of follow-up, the second patient had an ipsilateral recurrence in a site remote from the partial nephrectomy. Lane and Gill⁶⁹ recently reported 5-year recurrence-free, cancer-specific, and overall survival rates of 97.3%, 100%, and 86%, respectively in 37 patients with RCC treated with LPN. Only 1 patient had a local recurrence 4 years following surgery. Permpongkosol et al⁴⁹ compared 5-year survival rates in LPN and open partial nephrectomy in T1 tumors. Five-year disease-free and actuarial survival rates for 85 LPN patients were 91.4% and 93.8%, respectively. The survival rates for 58 open partial nephrectomies were 97.6% and 95.8%, respectively. No statistically significant differences in survival were noted between the two groups.

Despite the promising results in series of patients undergoing LPN, an open partial nephrectomy is still considered the gold standard treatment for patients with smaller renal tumors amenable to nephron-sparing surgery.

Laparoscopic Nephroureterectomy

Unlike TCCA involving the bladder, TCCA in the upper urinary tract is an uncommon urologic tumor. Most patients diagnosed with upper-tract TCCA who have no evidence of disease in the contralateral kidney and who have adequate renal function undergo complete nephroureterectomy. Excision of the entire ureter is routinely performed, as 30% to 60% of patients will develop disease recurrence in the remaining ureteral remnant. Attempts to manage upper-tract tumors endoscopically for renal preservation are usually reserved for patients with limited tumor burden, solitary kidneys, or renal insufficiency. A disadvantage of conservative endoscopic therapy includes the surgeon's inability to adequately resect upper-tract tumors due to limited working space within the ureter, renal pelvis, and renal calyces. This technical limitation likely promotes higher rates of cancer recurrence, progression, and clinical understaging.

Table 5. — Laparoscopic Nephroureterectomy

Series (year)	Technique	No. of Patients	Mean EBL (mL)	Mean Operating Room Time (mins)	Hospital Stay (days)	Lower Tract Recurrence (%)	Metastasis (%)	Follow-Up (mos)
Gill et al ⁷¹ (2000)	LNU	42	242	225	2.3	23	8.6	11
	Open	35	696	282	6.6	37	13	34.4
Kume et al ⁷² (2006)	LNU	28	NR	371	NR	69.2	NR	34.3
	Open	13	NR	229	NR	35.7	NR	55.7
Ou et al ⁷⁰ (2006)	HALNU	41	166	207.6	10	NR	NR	NR
Stifelman et al ⁷³ (2001)	HALNU	11	144	291	4.6	NR	NR	13
	Open	11	311	232	6.1	NR	NR	17

NR = not reported, HALNU = hand-assisted laparoscopic nephroureterectomy, EBL = estimated blood loss.

The traditional open approach to a nephroureterectomy included either one long incision from the flank to the lower abdomen or two separate muscle-splitting incisions. A laparoscopic nephroureterectomy (LNU) generally results in reduced blood loss and improved convalescence (Table 5).⁷⁰⁻⁷³ Laparoscopic management of upper-tract TCCA maintains the oncologic principles of open surgery, and early follow-up suggests that cancer control is comparable to the open technique. The LNU involves the en bloc resection of the kidney, ureter, and a cuff of bladder around the ipsilateral ureteral orifice. The laparoscopic nephrectomy is similar to that described for RCC apart from division of the ureter. The distal ureter is managed using one of five techniques: (1) open excision of the distal ureter and bladder cuff through a lower midline, Pfannenstiel, or Gibson incision,^{70,74} (2) the pluck technique,⁷⁵ (3) ureteral unroofing,⁷⁶ (4) the needlescopic technique,⁷¹ and (5) the extravesical stapling technique.⁷⁷ Matin and Gill⁷⁷ found that positive margin rates and bladder recurrence rates were less with their needlescopic technique compared with patients whose distal ureters and bladder cuffs were managed with an extravesical laparoscopic stapling approach. An additional complication with extravesical laparoscopic transection of the distal ureter and bladder cuff with a stapling device includes retained intravesical staples that could serve as a nidus for stone formation.⁷⁸ Finally, retroperitoneal recurrence has been reported in patients undergoing initial endoscopic resection of the bladder cuff and transmurial ureter (pluck technique).⁷⁹

Survival following nephroureterectomy depends on stage and grade.⁸⁰ Five-year survival rates exceed 90% for patients with Tis, Ta, or T1 disease and 44% for patients with T2 muscle invasive tumors.⁸¹ Patients with more locally advanced upper-tract urothelial tumors (T3, T4, or N+ disease) have a poor 5-year survival rate, ranging from 10% to 23%.⁸² Unfortunately, some reports suggest that the current treatment paradigm of surgery alone for patients with nonmetastatic disease has not improved survival over the last 20 years.⁸³ New paradigms incorporating multimodality approaches to treating patients with invasive upper-tract TCCA are required to improve patient survival.

Short-term local and distant recurrence rates are similar in patients undergoing LNU compared with traditional open surgery.⁸⁴ Kawauchi et al⁸⁵ reported their series of patients undergoing LNU and open nephroureterectomy. Follow-up in the patients undergoing open surgery was 48 months compared with a follow-up of 13 months in those undergoing LNU. Longer follow-up in the open surgery group likely accounted for the increased percentage of patients who experienced a local recurrence (38%) compared with the LNU group (9%). However, distant metastatic recurrences were similar in both groups (9% and 6%, respectively) indicating

that most distant recurrences usually manifest early in the follow-up period. Hattori et al⁸⁶ compared survival rates and recurrence rates of three surgical techniques for managing upper-tract TCC: laparoscopic nephrectomy with open distal ureteral resection (36 patients), pure LNU with laparoscopic stapling of the distal ureter and bladder cuff (53 patients), and complete open nephroureterectomy (60 patients). Three-year cancer-specific survival rates were 86%, 80%, and 81%, respectively, for the three groups. Bladder recurrence-free survival rates were 65%, 45%, and 51%.⁷⁵

Specimen Morcellation

Most kidney cancers are extracted from the peritoneal cavity intact. Morcellation involves specimen entrapment within an impermeable laparoscopic sac followed by piecemeal extraction of the surgical specimen with instruments such as ring forceps or specimen fragmentation with a mechanical morcellating device followed by specimen evacuation. Morcellation limits the extent of the incision required to remove an intact specimen, thereby potentially decreasing postoperative incisional pain, incisional related complications, and operative time required for closing an abdominal incision. Proponents of morcellation note that staging information can be obtained from preoperative radiographic studies and that pathologic criteria for predicting prognosis (eg, histology, Furhman grade, necrosis) are not lost when examining the morcellated specimen.⁸⁷ Although the technique improves cosmesis, some authors report no differences in operating time, pain, or hospital stay.⁸⁸

Critics of morcellation cite complications associated with this procedure, including local tumor spillage, trocar site recurrence, and major morcellation injury to a loop of bowel or colon.⁸⁹⁻⁹¹ There remain concerns that morcellation might result in the loss of important pathologic staging information that otherwise would be used to define postoperative requirements for cancer surveillance and to identify high-risk patients who might be candidates for trials involving adjuvant therapy. Svateck et al⁹² recently reported that 18.5 % and 21.2 % of patients with clinical T1 and T2 kidney cancers, respectively, were pathologically upstaged. These data are similar to results reported by Cohen et al,⁹³ who determined that 21.9% of patients undergoing LRN with cT1-N0 or cT2-N0 RCC were upstaged to pT3 disease based on pathologic assessment of the intact specimen.

Today, most urologists agree that proper techniques for specimen morcellation and extraction are safe. Pathologic staging information may be lost in some patients, thereby limiting the applicability of this technique in centers where trial participation requires the reporting of an accurate pathologic T stage. Gener-

ally, this technique is not recommended for patients with urothelial malignancies or for those undergoing laparoscopic partial nephrectomy.

Complications of Laparoscopic Renal Surgery

Complication rates associated with laparoscopic surgery decrease as the experience of the operating surgeon expands.^{94,95} Simon et al⁹⁶ presented complications of 285 laparoscopic renal cases, including 113 cases of LRN. Major complications occurred in 16 patients (5.6%), including 12 (4%) who required open conversion (6 emergency indications: 4 with hemorrhage that could not be controlled laparoscopically and 2 with splenectomy). Six patients had elective conversion because of failure to progress laparoscopically. Many urologists argue that elective conversion to an open case for failure to progress should not be considered a complication of the laparoscopic approach. Major complications in the remaining 4 patients included splenic laceration treated conservatively, tumor fragmentation during specimen retrieval, immediate postoperative hypotension requiring open exploration, and pneumothorax.⁹⁶ Pareek et al⁹⁷ recently reviewed the reported complications of laparoscopic renal surgery. Overall, 10.7% of patients undergoing a pure LRN experienced a major complication compared with 9.3 % of patients who underwent a hand-assisted LRN (no statistical significance). The most frequent major complications in the LRN group included venous and arterial bleeding (1.8% and 1.0%). In the hand-assisted LRN group, the most common major complications included wound infection (1.5%) and arterial hemorrhage (1.0%). Wound infection rates were significantly higher in patients managed with hand-assisted LRN compared with patients treated with pure laparoscopic techniques.

Steinberg et al⁴ compared complication rates in patients undergoing open surgery and LRN. Intraoperative complications occurred in 7.2% of patients who were treated with LRN for pT1 tumors, 7.7% of patients who underwent LRN for pT2 tumors, and 17.6% of patients who underwent surgery with standard open techniques for pT2 tumors. Although there was an apparent higher complication rate for the open group, the difference was not statistically significant. The most common intraoperative complication in each of the groups was vascular injury and hemorrhage. The rates of postoperative complications were similar (19.9%, 21.5%, and 26.5%, respectively). Interestingly, wound-related complications and postoperative ileus were higher in the laparoscopic groups compared with the open group, which the authors attributed to differences in recovery expectations and reporting by the operating surgeons.⁴

Complication rates associated with LPN are higher than rates reported for other laparoscopic renal surgeries.⁹⁸ To no surprise, complication rates are less with exophytic lesions (10%) compared with 47% for intraparenchymal lesions and 50% for renal hilar lesions.⁹⁹ Pareek et al⁹⁷ reported a major complication rate of 21% in their literature review of 591 patients undergoing LPN. The most common of these major complications included bleeding that required blood transfusion (4.4%), urinoma (3.9%), and vascular injury (2.5%). Other less frequent (less than 2% incidence) but major complications included cardiac dysrhythmia, renal failure, venous thrombosis, wound infection, retroperitoneal hematoma, and ureteral injury. Although LPN typically requires more advanced laparoscopic skills, the open conversion rate was only 1.9%. A small number of patients (1.4%) underwent reoperation.

Ramani et al⁵³ reported a detailed experience of complications associated with LPN. The overall complication rate in 200 patients was 33%: 5.5% intraoperative, 12% postoperative, and 15.5% delayed. Most complications (18%) were related directly to urologic issues. Nearly 1 in 10 patients (9.5%) experienced significant bleeding (intraoperative, postoperative, and delayed in 3.5%, 2%, and 4%, respectively). A urine leak occurred in 9 patients (4.5%). Leaks were managed in 8 patients with ureteral stents or treated conservatively in 1 patient. Only 2 patients required percutaneous drainage of an urinoma.

Conclusions

Laparoscopy is a minimally invasive option available to most patients with kidney cancer. The long-term cancer control rates in patients managed with LRN are equivalent to patients undergoing open surgery, provided that oncologic principles are maintained. For LPN and LNU, intermediate outcome data are encouraging. Longer follow-up is required to establish LPN and LNU as first-line treatment options comparable to standard open surgical techniques. The immediate benefits of laparoscopy are well established and include decreased blood loss, less pain, shorter perioperative convalescence, and improved cosmesis.

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